Frozen Aerated Confection

Technical Field of the Invention

This invention relates to a frozen aerated confection. More specifically, the invention relates to an ice cream product which is soft and extensible at -18°C.

Background to the Invention

US patent application publication 2001/0031304 A discloses a frozen aerated confection which exhibits an extensible character similar to that shown by a Turkish artisenal type of ice cream known as *Maras*. *Maras* ice cream comprises sahlep which is an extract from the roots of orchids and it is thought that it is sahlep which contributes to the extensible quality of *Maras* ice cream.

In US 2001/0031304 A, the frozen aerated confection does not comprise sahlep or any other product from orchids. Preferably, the confection comprises a polysaccharide such as xanthan gum, guar gum, or sodium carboxymethyl cellulose (CMC). In addition the confection preferably comprises one or more proteins selected from milk, soya or whey protein. The overrun of the confection is in the range 15-80%.

The inventors have observed that when the frozen aerated confection disclosed in US 2001/0031304 A is removed from a domestic freezer at -18°C, it is not apparent to the consumer that the confection has an extensible quality because it is too hard. The extensible character of the confection only becomes apparent on softening the product by warming it to -12°C.

A further problem with the confection disclosed in US 2001/0031304 A is that the extensibility generally decreases as the overrun increases beyond 30%.

Tests and Definitions

The number average molecular weight (M_n) is a number weighted averaged molecular weight defined by the following equation:

$$M_n = \frac{\Sigma w_i}{\Sigma (w_i/M_i)} = \frac{\Sigma N_i M_i}{\Sigma N_i}$$

where w_i is the mass of species i, M_i is the molar mass of species i and N_i is the number of moles of the species i of molar mass M_i. The mean number average molecular weight is the number average molecular weight of a blend of two or more, in this case, freezing point depressants.

Overrun is defined by the following equation

$$overrun = \frac{(volume.of.ice.cream) - (volume.of.premix.at.ambient.temperature)}{(volume.of.premix.at.ambient.temperature)} \times 100$$

Freezing point depressants as defined in this invention consist of: monosaccharides; disaccharides; oligosaccharides containing from three to ten monosaccharide units joined in glycosidic linkage; corn syrups with a dextrose equivalent (DE) of greater than 20 preferably > 40 and more preferably > 60; glycerol; erythritol; arabitol; xylitol; sorbitol; mannitol; lactitol; malitol; or any combination thereof.

Monosaccharides and disaccharides include sucrose, arabinose, ribose, xylose, dextrose, galactose, mannose, fructose, lactose, maltose, raffinose and stachyose.

Corn syrups are complex multi-component sugar mixtures and the dextrose equivalent is a common industrial means of classification. Since they are complex mixtures their number average molecular

weight (M_n) can be calculated from the equation below (Journal of Food Engineering, 33 (1997) 221-226),

$$DE = {}^{100}/_{M_N}/180.16$$

Extensible confection refers to a frozen aerated confection with an extensibility of at least 30%. At an extensibility of less than 30%, the consumer does not generally perceive the confection as being extensible.

Measurement of extensibility

In the examples that follow, the extensibility was measured using the following procedure, which is illustrated with reference to the figures in which:

Figure 1 shows a cutter used to stamp a test piece;
Figure 2 shows a test piece grip;
Figure 3 shows the arrangement of two grips with a metal gauge; and
Figure 4 shows a test piece broken at the shoulder.

A 500 ml block of ice cream of dimensions 92 mm x 38 mm x 140 mm was removed from a cold store at -25°C and allowed to soften at 25°C. The block was cut into 10 mm wide strips using a serrated knife and following the pre-drawn guidelines on the block. Thus from one block, 14 strips having dimensions of 92 mm x 38 mm x 10 mm were cut off.

The strips were placed on a silicon paper covered portable hard flat surface, for example a hard plastic chopping board. A shaped test piece was then stamped from each of the strips using a cutter which is shown in Figure 1. The cutter has an overall length of 80 mm and a width at its widest point adjacent the ends of 23 mm. An indented area (11) is defined substantially symmetrical about the

middle point of the length of the cutter. The indented area has a width of 10 mm and a length of 60 mm.

The cutter was warmed in hot water at 50-60°C and at least 6 test pieces stamped from the aforementioned strips. The test pieces were then returned to a cold store at -25°C on the silicon paper and hardboard for a minimum of 90 minutes. As the test pieces should not be held at 25°C for more than 13 minutes, the time for cutting and stamping did not exceed 8 minutes.

The test pieces were then removed from the cold store at -25°C and placed into test grips. The test grip design is shown in Figure 2 and comprises 2 Perspex™ plates (21) joined together with a C clip (22) and a stainless steel pin (23), the C clip (22) comprising an M4 screw (24). Mounted on the opposing faces of each Perspex™ plate (21) is a rubber pad (25), each of which has a dimpled surface. The distance from the distal end of the rubber pad to the C clip (22) is 25 mm and the spacing between the rubber pads (25) is 23 mm. The width of each rubber pad (25) is 18 mm. The rubber pads (25) comprise Foulds conveyor belt material model V100 two-ply polyester with a polyvinyl chloride top surface. The rubber pads (25) are attached to the Perspex™ plates (21) with adhesive whereby the dimpled surface of each rubber pad (25) is free to grip the test pieces.

One test grip (33) was placed on each end of the test piece (32) as shown in Figure 3. The rubber pads (25) were closed to a gap no smaller than 8 mm. A metal gauge (31) was used to ensure that the pair of grips were correctly located ensuring the distance between the two grips was 60 mm.

In Figure 3, the metal gauge (31) is shown attached to a pair of test grips (33) holding a test piece (32). The metal gauge (31)

has a total length of 136 mm and sets the distance between the screws of each C clip at 120 mm. The test piece, test grips and metal gauge were then placed in a portable freezer set at -18°C for 10-120 minutes.

Testing was conducted on an Instron 4501 mechanical test machine fitted with a 10 N load cell. The test was conducted within a temperature control cabinet set to -18°C. After the test piece was attached to the mechanical test machine via the test grips, the metal gauge was removed and the test piece allowed to equilibrate at -18°C for 2 minutes before the test was performed.

The test was performed by pulling the test piece apart with the test grips moving away from each other at a relative speed of 50 mm per minute. The force (F) required to pull the test piece and the displacement of the test grips (ΔL) were continually recorded during the test. Any test in which the test piece slipped within either grip or broke at the shoulder (41) of the test piece as shown in Figure 4 was rejected. The test was completed when the test piece is broke. A minimum of 6 valid tests was required to provide a measurement of extensibility for a test ice cream.

The displacement of the test grips at which the force drops to zero after passing through a maximum load is the point at which the failure of the test piece occurs.

A percentage strain to failure E_f is defined as the displacement to failure divided by the original gauge length of test piece (L_0) multiplied by 100. The original gauge length is that portion of the test piece which is 10 mm wide, thus the original gauge length is 60 mm. The mean percentage strain to failure of at least 6 valid tests defines the extensibility of the ice cream under test.

Measurement of mechanical firmness

Mechanical firmness was measured in accordance with the following procedure.

Mechanical firmness provides an indication of softness. Mechanical firmness is given by the maximum true stress (Pa) which can be obtained from a true stress versus true strain curve (Richards, C.W. (1961) *Engineering materials science*. Brooks/Cole Publishing, Belmont, MA; Green, D.J. (1998) *An introduction to the mechanical properties of ceramics*. Cambridge University Press, Cambridge, UK).

The true stress (σ_t) can be calculated from the force measurements obtained from the extensibility test and is given by

$$\sigma_t = F(L_0 + \Delta L)/(A_0 L_0)$$

where A_0 is the cross-sectional area of the original gauge length.

The true strain (ϵ_t) is given by

$$\epsilon_t = \ln((L_0 + \Delta L)/L_0)$$

Determination of the texture profile

The texture profile was determined by a sensory panel of 10 or more trained assessors.

The technique employed combined aspects of both the Spectrum™ and Texture Profile™ methodologies (Lawless, H.T. and Heymann, H. (1999) *Sensory evaluation of food: principles and practices*. Chapman & Hall, London; Meilgaard, M., Civille, G.V. and Carr, B.T. (1991) Sensory evaluation techniques - 2nd edition. CRC Press, London). The technique is a descriptive method to describe the

textural characteristics of most food products during consumption. The eating procedure, technical lexicon and scales are all standardised, with a number of reference products along each scale to enable the quantitative rating of intensity relative to all foods.

The trial involved a three replicate assessment. Samples were served in plastic pots at -18°C and the trained assessors were asked to assess the attributes listed in table 1 hereinbelow in accordance with the procedure set out in the same table. The data was analysed using ANOVA (analysis of variance) and multiple comparison testing. The accepted significance level was 5% or $p=<0.05$.

In relation to the firmness of the ice creams, the most relevant attributes are firmness (semi-solid) and hardness/firmness (solid).

Table 1: Sensory Attributes

Assessment	First manipulation	First manipulation
Attribute	Firmness	Hardness/Firmness
Solid / semi-solid	semi-solid	solid
Definition	Force required to compress between tongue and palate	Force required to bite through the sample
Evaluation Procedure	Place ½ tsp of sample in mouth and compress between tongue and palate	Bite through the sample with the incisors
Anchors	Low (soft) High (firm)	Low (very soft) High (very hard)
References	Whipped cream: 2 Cream cheese: 8-9 Paté: 14	Cream cheese: 1 Hard mature cheddar: 7.5 Almond: 11 Hard candy: 14.5

Brief Description of the Invention

This invention overcomes the aforementioned problems by providing, in a first aspect, a frozen aerated confection comprising freezing point depressants in a total amount of 26-40% weight by weight, the freezing point depressants having a mean number average molecular weight of less than or equal to 320, characterized in that the confection has an extensibility of at least 30% at -18°C.

Without wishing to be bound by theory, the inventors have observed that the softness of a frozen aerated confection comprising freezing point depressants in a total amount of 26-40% weight by weight, the freezing point depressants having a mean number average molecular weight of less than or equal to 320, is a function of the viscosity of the non-frozen matrix phase as well as the phase volume of ice. Since the viscosity of the non-frozen matrix phase and the ice phase volume are, in part, a function of the mean number average molecular weight of the freezing point depressants, the softness of the confection is, in part, determined by the mean number average molecular weight of the freezing point depressants.

When the mean number average molecular weight of the freezing point depressants is much in excess of 320 at a total freezing point depressant amount of 26-40% weight by weight, the extensible character of the confection is maintained but is not apparent to the consumer at -18°C because the confection is too hard.

Thus by maintaining the total amount of freezing point depressants in the range of 26-40% weight by weight and controlling the mean number average molecular weight of the freezing point depressants at less than or equal to 320, the confection is soft enough when, removed directly from a domestic freezer, for the consumer to perceive any extensible character.

Preferably the total freezing point depressant range is 28-39% weight by weight and the mean number average molecular weight range is 200 to 300. In particular, the total freezing point depressant range is 29-36% weight by weight and the mean number average molecular weight range is 200 to 250.

The extensibility of the confection is preferably at least 40% at -18°C, and more preferably at least 50% at -18°C.

Preferably the freezing point depressants comprise at least 98% weight by weight monosaccharide, disaccharide, oligosaccharide and corn syrup. In particular the monosaccharide, disaccharide and corn syrup is selected from the group consisting of sucrose, dextrose, lactose, fructose, maltose, corn syrup of DE greater than or equal to 53 and mixtures thereof.

Preferably the freezing point depressants comprise at least 98% weight by weight monosaccharide, disaccharide, oligosaccharide.

Preferably the frozen aerated confection an effective amount of polysaccharide selected from the group consisting of xanthan gum, guar gum, sodium carboxymethyl cellulose and mixtures thereof. More preferably the polysaccharide is guar gum.

Preferably the confection comprises an effective amount of at least one protein. More preferably the protein is selected from the group consisting of milk protein, soya protein, whey protein and mixtures thereof.

Preferably the frozen aerated confection has an overrun in the range 0-120%. More preferably the frozen aerated confection has an overrun in the range 30-120%. Most preferably the frozen aerated confection has an overrun in the range 30-90%. Equally most

preferably the frozen aerated confection has an overrun in the range 80%-120%.

In a second aspect of the invention, a frozen aerated confection is provided comprising freezing point depressants in a total amount of 26-40% weight by weight, the freezing point depressants having a mean number average molecular weight of less than or equal to 320, characterized in that the frozen aerated confection additionally comprises an effective amount of one or more polysaccharides selected from the group consisting of xanthan gum, guar gum, sodium carboxymethyl cellulose and mixtures thereof, and an effective amount of at least one protein.

Preferably the polysaccharide is guar gum at a level of 0.4-0.9% weight by weight.

Desirably the protein is at a level of 1-5% weight by weight and is selected from the group consisting of milk protein, soya protein, whey protein and mixtures thereof.

Preferably the total freezing point depressant range is 28-39% weight by weight and the mean number average molecular weight range is 200 to 300. In particular the total freezing point depressant range is 29-36% weight by weight and the mean number average molecular weight range is 200 to 250.

Preferably the freezing point depressants comprise at least 98% weight by weight monosaccharide, disaccharide, oligosaccharide and corn syrup. In particular the monosaccharide, disaccharide and corn syrup is selected from the group consisting of sucrose, dextrose, lactose, fructose, maltose, corn syrup of DE greater than or equal to 53.

Preferably the freezing point depressants comprise at least 98% weight by weight monosaccharide, disaccharide, oligosaccharide.

Preferably the frozen aerated confection has an overrun in the range 0-120%. More preferably the frozen aerated confection has an overrun in the range 30-120%. Most preferably the frozen aerated confection has an overrun in the range 30-90%. Equally most preferably the frozen aerated confection has an overrun in the range 80%-120%.

Examples

Ice cream was prepared to the formulations set out in table 2 hereinbelow and tested in accordance with the test procedures set forth hereinabove.

Comparative example 1 was a non-extensible ice cream and comparative example 2 was a standard extensible ice cream.

The mean number average molecular weight of the freezing point depressants (FPD) were calculated from the equation set forth hereinabove. Total protein content (not shown) and freezing point depressant content (not shown) were also calculated by simple arithmetic.

Ice creams were prepared to the formulations set out in table 2.

Table 2: Ice Cream Formulations

	Comparative example 1	Comparative example 2	Example 1	Example 2	Example 3
Ingredients	%	%	%	%	%
CNO	9	8.2	-	-	5
Butterfat	-	-	4	4	-
SMP	7.4	7.88	8	8	8
Whey solids	2.6	-	-	-	-
MGP	0.39	0.4	0.15	0.15	0.15
Sucrose	13.9	14	8.125	8.125	12.5
Dextrose	-	-	19.35	23.5	19.4
Fructose	-	-	-	-	-
Glycerol	-	-	-	-	-
65 DE corn syrup	-	8	-	-	-
LF9 corn syrup (63 DE)	4.6	-	-	-	-
MD40	-	2	-	-	-
Lactose	-	-	4.375	-	-
LBG	0.284	-	-	-	-
Carrageenan C	0.041	-	-	-	-
Guar gum	-	0.7	0.72	0.72	0.72
Flavour	0.285	-	-	-	0.1125
Beta Carotene	0.0013	-	-	-	-
Turmeric	-	-	-	-	0.13
Colour	-	-	-	-	0.15
Water	61.4987	58.82	55.255	55.25	53.875
Total FPD	22.69	26.3	34.25	33.65	34.29
Total protein	3.37	2.76	2.8	2.8	2.8
FPD mean Mn	332.0	329.1	234.1	217.8	234

Table 2: Ice Cream Formulations

	Example 4	Example 5	Example 6	Example 7	Example 8
Ingredients	%	%	%	%	%
CNO	-	-	-	-	-
Butterfat	4	4	4	4	4
SMP	8	8	8	8	8
Whey solids	-	-	-	-	-
MGP	0.15	0.15	0.15	0.15	0.15
Sucrose	-	-	29	20.7	4.0625
Dextrose	-	-	-	-	19.375
Fructose	28.5	19.7	5.94	4.446	-
Glycerol	2	2	-	-	-
65 DE corn syrup	-	-	-	-	-
LF9 corn syrup (63 DE)	-	-	-	-	10.2
MD40	-	-	-	-	-
Lactose	-	-	-	-	-
LBG	-	-	-	-	-
Carrageenan C	-	-	-	-	-
Guar gum	0.72	0.72	0.72	0.72	0.72
Flavour	-	-	-	-	-
Beta Carotene	-	-	-	-	-
Turmeric	-	-	-	-	-
Colour	-	-	-	-	-
Water	56.62	65.42	52.18	61.974	53.4825
Total FPD	34.66	25.86	39.10	29.30	33.79
Total protein	2.80	2.80	2.80	2.80	2.80
FPD mean Mn	180.5	180.6	301.0	301.0	224.5

CNO ≡ coconut oil

LF9 glucose syrup (63 DE) ≡ 63 DE corn syrup at 78% weight by weight solids

SMP ≡ skimmed milk powder (52% weight by weight lactose and 35% weight by weight milk protein)

MGP ≡ monoglyceryl palmitate (emulsifier)

MD40 ≡ DE 40 corn syrup at 95% weight by weight solids

LBG ≡ locust bean gum

65 DE corn syrup ≡ 65 DE corn syrup at 80% weight by weight solids

Whey solids ≡ Esprion 300 (52% weight by weight lactose and 30% weight by weight whey protein)

Dextrose ≡ dextrose monohydrate

The ice creams were prepared in accordance with the following procedure.

All the ingredients were blended together in an agitated heated mix tank after which the blend was subjected to high shear mixing at a temperature of at least 65°C for 2 minutes in order to hydrate the stabilisers. Excessive temperature was avoided to prevent damage to heat labile components and the formation of cooked off flavours.

The blend was then subjected to homogenisation to reduce the bulk of the fat droplets to below 1μm in diameter by homogenising at a pressure of 150bar and a temperature of 70°C using a valve homogeniser.

As examples 1 and 2 and comparative example 2 were rather viscous due to their high levels of guar, they were heated to 80°C prior to homogenisation to facilitate processing thereby enabling the blends to flow more readily through the pasteuriser and the homogeniser.

In order to conform to public health requirements the blend was pasteurised by heated the blend to 83°C and holding for 20 seconds. The pasteurised blend was then rapidly cooled to a chill temperature of 4°C. The blend was then held at 4°C to age.

The blend was then frozen using a continuous freezer known as a votator or scrape surface heat exchanger. These devices freeze the blend and incorporate sufficient air to deliver the desired overrun. The ice cream was extruded at -10°C.

Following freezing the ice cream was subjected to hardening by blast freezing to -35°C thereby reducing the temperature of the ice cream to close to the final storage temperature of -25°C.

Results

The results of extensibility tests are shown in table 3. Both example 1 and comparative example 2 were prepared at 30% overruns. Comparative example 1 was prepared at 60% overrun.

Table 3: Extensibility Measurements

	Overrun (%)	% Mean Strain to Failure	Standard Deviation
Comparative example 2	30	134	72
Example 1	30	155	65
Example 2	30	83	32
Comparative example 1	60	13	2

The results show that the extensibility of example 1 is comparable to comparative example 2, which is the standard extensible ice cream. Comparative example 1, which is the non-extensible ice cream, exhibited very low values of extensibility.

Extensibility measurements were also carried out on example 1 and comparative example 2 at overruns of 30%, 50%, 100% and 120%. The results are summarised in table 4 hereinbelow. (The sample of comparative example 2 was produced using the same formulation but on a different occasion to the sample of comparative example 2 whose measurement results were shown in table 3.)

Table 4: Extensibilty as a Function of Overrun

	Overrun (%)	% Mean Strain to Failure	Standard Deviation
Comparative Example 2	30	113	31
	50	60	13
	100	50	27
	120	54	21
Example 1	30	155	65
	50	124	44
	100	82	24
	120	125	56

In table 4, it is apparent how increasing the overrun leads to a decrease in the extensibility of comparative example 2 (the standard extensible ice cream). In comparison, and rather surprisingly, the extensibility of example 1 remains relatively stable on increasing the overrun.

The results of the mechanical firmness tests are shown in table 5. The data recorded during the extensibility tests was used to calculate the true stress (σ_t) and true strain (ϵ_t) values in accordance with the method set forth hereinabove.

Table 5: Maximum True Stress Measurements (in kPa)

	Comparative Example 1	Comparative Example 2 (30% overrun)		Example 1 (30% overrun)		Example 2 (30% overrun)
		Sample 1	Sample 2	Sample 1	Sample 2	
	14.9	17.6	17.7	4.10	4.56	4.04
	27.1	16.1	16.1	3.83	5.12	3.83
	14.4	24.4	15.4	3.67	4.26	3.67
	16.2	21.8	18.4	4.03	3.48	4.10
	19.6	15.5	11.3	4.53	5.41	4.52
	17.6	18.3	11.6	5.13	6.32	5.13
	28.8	11.1	24.4	8.04	9.55	3.62
		11.6	21.8	6.73		8.04
		9.71				6.69
Average	19.8	16.2	17.1	5.01	5.53	4.85
Standard deviation	5.86	4.94	4.55	1.57	1.99	1.54

Table 5 shows that examples 1 and 2 are softer than comparative example 2 (the standard extensible ice cream) at -18°C. Examples 1 and 2 are also softer than comparative example 1 at -18°C.

The results of the texture profile are summarised in table 6 hereinbelow.

Table 6: Texture Profile Measurements

Attribute	Comparative Example 1	Comparative Example 2 (30% overrun)	Example 1 (30% overrun)	Comparative Example 2 (100% overrun)	Maximum least significant difference
Firmness (semi-solid)	9.19	11.16	6.52	5.58	1.3
Hardness/ firmness (solid)	3.61	5.47	2.47	2.22	1.09

Example 1 at 30% and 100% overrun were not significantly different from each other but were significantly less firm than the comparative examples.

Examples 3 to 8 were tested non-mechanically (manually) and observed to display extensible character at -18°C.